Research on the Architecture of Cloud Computing Ground Information Port Based on SDN

Wenxi Wu, Lei Shi, Xiangge Liu
China Academy of Electronics and Information Technology, China
wuwenxi_caeit@126.com

***Abstract*—With the rapid development of information technology and continuous expansion of the application field, the space-ground integrative information network will be an important strategic infrastructure of the country. The ground information port will play a significant role in the space-ground connection, data processing and product service as an important ground node in the space-ground integrative information network. According to the design of the cloud computing and the network design of the SDN, this paper proposes an SDN-based cloud computing ground information port architecture, and discusses the SDN-based network interconnection and traffic management in detail.**

Keywords—Ground Information Port; SDN; Cloud Computing; Space-ground Integrative.

I. INTRODUCTION

Currently, there are more than 1300 orbiting satellites that are used for reconnaissance, navigation and communication in the whole world. The resulting space-based data has exploded and scaled to the petabyte level. The three satellite centers in China, National Satellite Meteorological Center stores about 1.1 PB meteorological satellite data[1], China Resources Satellite Application Center stores about 3.5 PB earth observation satellite data[2], National satellite Marine Application Center stores about 25 TB Ocean satellite data[3]. Although the data processing capabilities of the satellite have been improved continuously, it can only preliminarily filter and process the space-based data, most of the data has to be sent to ground for the further processing. Another big problem for the space-based data processing is that most of the data is unstructured, such as the location information acquired by visible light, infrared detection, microwave, laser and electromagnetic. All these kinds of data are hard to describe in the two-dimensional logical way of the traditional relational database.

Recently, cloud computing technology has been developed from theoretical research to commercial applications, and has a deep impact on the development of all industries[4]. All the server and storage on the Cloud Computing platform are virtualized, which increases the equipment utilization by 60%, compared to the traditional data center in the same scale. In the traditional data center, computing, storage and network source are tightly coupled, developing the system in stovepipe way. While the cloud computing platforms are loosely couple, it can adjust the resource allocation according to the consumption proportion of the resource. The scalability of traditional data center is limited to the design of system, computer room and network, while the modular expansion capability of the cloud computing platform fixes this problem very well[5]. In a word, the traditional data center can't meet the requirement of processing massive, heterogeneous space-based data in the new era. Therefore, in the construction of space-ground integrative information network, it is very important to build the ground information port based on the cloud computing platform[6].

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II. RESEARCH AND APPLICATION ABOUT CLOUD COMPUTING AT HOME AND ABROAD

A. Relevant Concepts of Cloud Computing

In order to solve the problem of big data processing, Google, Amazon and other companies proposed a "cloud computing" concept as early as 2006. According to the definition of the US National Institute of Standards and Technology (NIST)[7], cloud computing is a computing model that can use the Internet to access a shared pool (including computing devices, storage devices, applications, etc.) on demand conveniently at anytime and anywhere.

B. Characteristics of Cloud Computing

- Resource virtualization: Resources are managed in a shared pool way, use the virtualization technology to allocate resources to different users, the placement, management and allocation strategy are transparent to the user[8].
- Elastic scalability: The scale of the service can be quickly retractable to automatically adapt to the dynamic changes in the business load. The resource usage of user is inconsistent with the demand of business, to avoid service quality degradation or resource waste due to the overload or redundancy of the server.
- Provide services according to demand: provide users with applications, data storage, infrastructure and other resources as a service, allocate the resource automatically according to customer's requirement without the intervention of system administrator.
- Metering charge of resources: the cloud computing service is measurable, standard payment is based on the usage of the user. In the storage and broadband network technology, this pay-as-you-go model has been widely used.

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- Flexible and convenient access: users can use a variety of terminal equipment (such as PC computers, laptops, smart phones, etc.) to access the cloud computing services anytime, anywhere through the network.
- Economic and energy-saving: cloud computing uses amount of business machine organized in clusters to achieve the same performance, which cost much less than building up a super computer[9].

C. *Architecture of Cloud Computing*

Generally, cloud computing architecture consists of five parts, which are application layer, platform layer, resource layer, user access layer and management layer. As shown in Fig. 1.

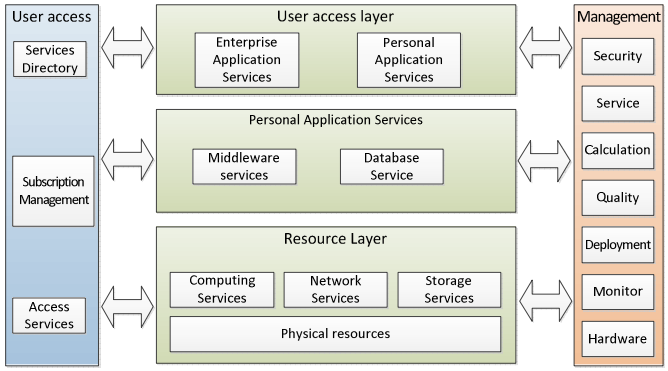

Fig.1 Cloud Architecture

III. ARCHITECTURE OF SPACE-GROUND INTEGRATIVE GROUND INFORMATION PORT BASED ON THE CLOUD COMPUTING

A. *The Definition of Ground Information Port*

The ground information port is a cloud computing platform that set up according to the unified standard based on the cloud architecture, it provides one-stop service of the space-based data, functional service and resource service, which can gather, process and distribute the geographic information, remote-sensing information and navigation data, formed the service mode that space-based data processed in the cloud and information consumption served in the terminal.

B. *Key Technologies of the Ground Information Port*

1) Virtualization.

Virtualization technology is the foundation and premise of cloud computing, aiming at allowing more operators to use the computing systems with terminal device through a virtual machine, to make full use of the expensive hardware resources. Virtualization technology makes it possible to share the distributed virtual environment in the underlying structure. For now, the virtual technology has realized the logical abstraction and unified representation of the resources. Virtualization technology not only eliminates the differences in large-scale heterogeneous servers, but also greatly reduces the complexity of cloud computing system management with its scalability and flexibility. That way it can improve the utilization of resources to keep the cost down and improve the operating efficiency.

2) Characteristics of SDN

a) Centralized and efficient management of the network management and maintenance.

b) Flexible networking and multi-path routing.

c) Intelligent deployment and migration of the virtual machine.

d) *Supportive of massive virtual tenants.*

SDN has the characteristics of centralized control, network virtualization and network opening, which can meet the requirements of the ground information port very well[10]. The centralized control can satisfy the requirements of the physical dispersion and logic concentration of the ground information port, realize the unified control and centralized optimization. The network virtualization can get more network service innovation for the internet service. The openness of the network can make the ground information port internet application innovation more convenient. Using SDN for the traffic scheduling and resource management is an important approach for the cloud service provider to become intellectualized.

C. *The Architecture of Ground Information Port*

Combined with the cloud computing architecture, the ground information port adopted the architecture which has three layers in horizon to meet the requirement of space-ground integrative information network. Shown as the Fig.2.

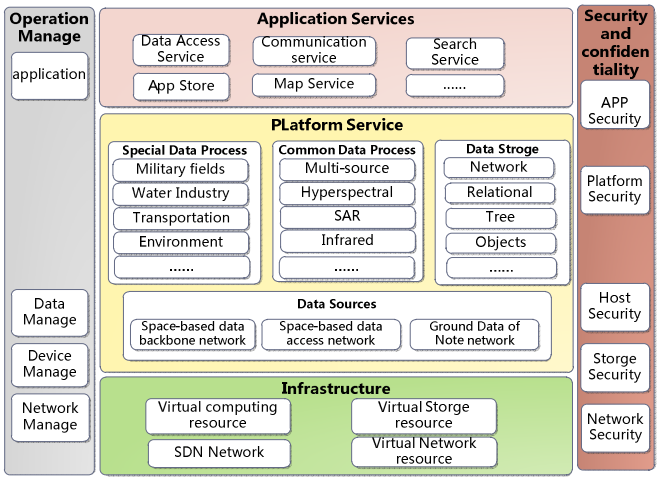

Fig.2 Architecture of Ground Information Port

- The infrastructure layer provides the ground information port upper layer services or end users with virtualized computing resources, storage resources and network resources via network, delivers infrastructure as a service.
- The platform service layer includes general data processing, dedicated data processing, database system and the access of information port. In the space-ground integrative ground information port, mainly related data are space-based communication and remote sensing data, data processing is mainly for the processing of remote sensing data.

- The application service layer works on data collection and mining from the preprocessed space-based data provided by the platform service layer, provide the users with final information product.
- The operation and maintenance management part is responsible for network management, equipment management, data management and application management.
- The security and confidentiality part is responsible for network security, storage security, host security, platform security and application security.

D. Interconnect Architecture of the Ground Information Port Based on SDN

The internetwork between the ground information ports have heavy network traffic, strong suddenness and short period, which requires multi-path routing, load balancing, dynamic supply on demand of bandwidth, centralized management and global control abilities of the network. Usually the internetwork between the ground information ports is wide area network, has a high network establishing cost, and needs to support multi-tenants and multi-service. But the current wide area network is limited by the traditional distributed routing computing and the lack of the network resources, has a low utilization of the link bandwidth. With the adoption of SDN technology, we can collect the network requirement of the ground information ports themselves and the communication network requirement between them through deploying the unified ground information port network controllers, to realize the visualized operation of network traffic. Use the global centralized control to compute and schedule in a unified way, implement flexible allocation of bandwidth on demand, maximally optimize the network, improve resource utilization. Google has applied the SDN technology among its data centers, and it has been proved to be a remarkable achievement that the link utilization between data centers is increased to nearly 100%[11]. Below is analysis and elucidation of the ground information port interconnect architecture based on SDN.

Usually, SDN-based data center interconnect architecture is comprised of four parts: internal VXLAN network of the ground information port, wide area backbone network between ground information ports, ground information ports business collaboration control platform and cloud service management platform.

1) Internal VXLAN network: large bandwidth, low-latency, scalable two-layer network is required in ground information port. The usual practice is to deploy SDN switches for the quick synchronization and migration of the virtual resources and network strategy, make the network, computing resources and storage resources closely coordinated, achieve efficient control of global resources. The internal VXLAN network use the virtual switch (vSwitch) to implement the two-layer overlay network technology based on the physical network[12] (such as VXLAN), physical network, virtual network interconnection gateway (software realization of virtual router, virtual DHCP, NAT, firewall, virtual load balancing, virtual VPN) and other functions. The internal VXLAN network implements 3 west-east layers interworking distributed routers and west-east traffic isolation distributed firewalls. It implements the internal network configuration and the control of monitoring, scheduling, traffic, automation in the ground information port.

2) Wide area backbone network: the network between ground information ports have several choices: bare fiber, renting MPLS/IP network of providers, metropolitan area network, Internet or dedicated WAN. Choose the corresponding interconnection technology according to different choices. Self-build WAN and bare fiber have a good scalability and flexibility, there is a wide range of Internet technology options for them. Bare fiber network requires the user have fiber or the transmission resources in the present network, which is a relatively high demand for the user. But from the point of performance, it could be the optimal choice. In the case of sufficient fiber, the physical layer network can be interconnection via 100Gbit/s wavelength division multiplexing transmission system.

3) Business collaboration controller: based on WAN, centralize the user network strategy on the controller side via SDN controller. Responsible for centralized management of the network configuration of the ground information port, and the flow forwarding control of the VXLAN NVE transponder. Through the centralized control of the controller, deployment of traffic engineering and other applications, it can efficiently adjust the end-to-end path of the whole network service to make efficient use of network resources. The controller can detect and report the fault in real time, predict and handle the business impact rapidly, simplify the network operation management, improve the business configuration speed and achieve a rapid upgrade of the network. The control platform and exchange nodes are using unified control and synchronization protocol. The control platform supports Restful API northward, to achieve rapid business customization and automatic distribution. It supports Open Flow and CLI interfaces, controls the physical network and virtual network.

4) Cloud service management platform: SDN controller provides REST API service through northward interface to integrate with the scheduling system or custom-developed application system. SDN controller provides the upper cloud management platform (such as Open stack, Cloud Stack) with the programmable API through the Restful API, provide the self-service for the tenant, realize the automatic deployment of business. Most of the mainstream SDN controllers have achieved interfacing with Open Stack Neutron plugin through the northward Neutron Rest API, the network level scheduling of Open Stack is completed by the butted controller.

E. Traffic Management of Ground Information Port Interconnect Network

The ground information port traffic is divided into north-south traffic and east-west traffic. The north-south traffic is mainly user access information, east-west traffic includes the

data synchronization and data backup inside or cross the ports, the traffic between the ports is transmitted by Internet. On the one hand, the strong suddenness of the Internet traffic can't guarantee the quality of synchronous traffic, on the other hand, it is not possible to route depend on the link load according to the existing routing protocol. Therefore, there is a problem of partial link congestion and low utilization of the whole network. The traffic engineering networking solution based on SDN architecture can solve the above problems and improve the bandwidth utilization. The principle of SDN to solve the traffic scheduling between information ports is shown as Fig. 3.

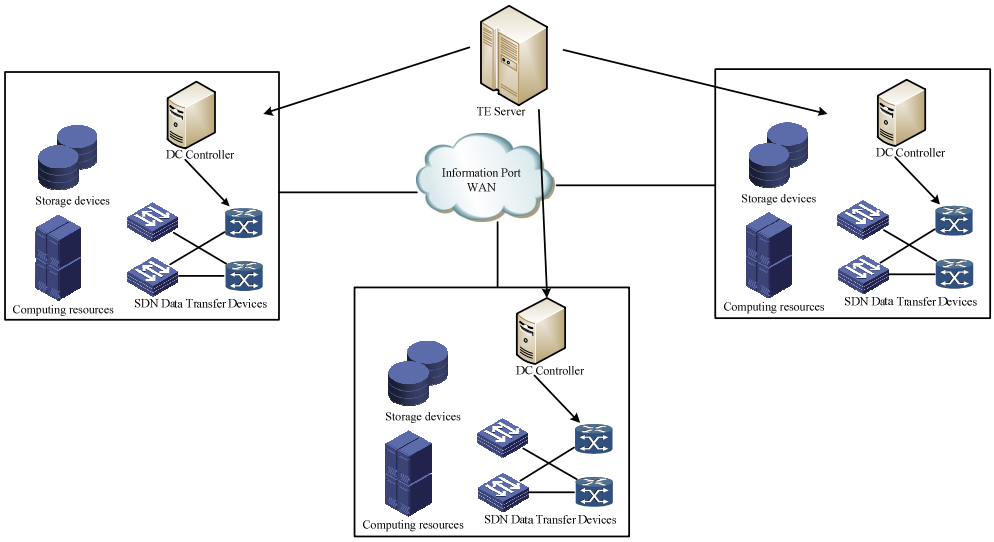

Fig.3 Traffic scheduling principle

The route computing of traditional network is either IP routing calculation with no bandwidth guaranteed, or the MPLS traffic engineering algorithm with bandwidth requirement. In both methods, the network node takes itself as the center then calculate a path to the destination, this routing calculation mode is difficult to obtain the optimal route. IP routing calculation is completely based on network topology, while in the traditional network there are some nodes don't have the whole network topology, which can only calculate the local shortest path. On the other hand, the acquisition and maintenance of the network topology depend on the distribution mechanism of the network topology (such as OSPF, ISIS protocol topological transitivity). When the network topology changes and the new topology has not yet spread to the whole network, the node which hasn't updated the topology are still routing according to the outdated network topology.

Using SDN architecture to realize centralized traffic engineering (TE) management of the ground information port interconnection network multi-tenant traffic path, come out with the optimal traffic path deployment solution of the whole network. TE system mainly includes the following parts.

1) OF Controller: Openflow control module, TE subsystem and physical forwarding devices in the network layer use the Openflow protocol, send the flow table to the physical equipment through OF control module and acquire the statistical information.

2) Topology: The global topology resources database which consists of the whole network physical topology, physical link bandwidth capacity and other information is the resource foundation of the TE algorithm module.

3) TE/SLA DB: Maintain the different SLA needs from all the tenants, each tenant can apply for the TE service path concurrently.

4) TE algorithm: From the perspective of global resources optimization, provide flexible service path calculation for different tenants, support different types of SLA needs of tenants, support different optimization objectives.

5) Tenant and Service Paths Management: provide the basis for graphical interface operation and the foundation of the device flow table.

6) Open API: Users can define different types of SLA and different optimization targets through the open programmable interface.

TE system can also monitor and manage the real-time traffic, service path of the tenant and the resource utilization of the whole network.

IV. SUMMARY

The cloud computing ground information port use an architecture that provides the computing , storage and network resources shared by multiple tenants. The proposal and development of SDN provides a new solution for the cloud computing ground information interconnection network. According to the design of the cloud computing and the network design of the SDN, this paper proposes an SDN-based cloud computing ground information port architecture, and analyzes the SDN-based network interconnection and traffic management.

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